

DSN Portable Zero Delay Assembly

E. J. Serhal, Jr., and T. Y. Otoshi

Radio Frequency and Microwave Subsystems Section

This article presents design and test data on portable zero delay assemblies that have recently been delivered to DSS 14, 43, and 63. These portable assemblies are field-use delay standards that will be used to periodically calibrate the Block IV Translator ranging paths at each 64-m antenna Deep Space Station.

I. Introduction

The Block IV Translator Method (Ref. 1) is currently being used to determine the ground station range delays at all 64-m antenna Deep Space Stations (DSS). The validity and accuracy of this method are dependent upon the Block IV Translator ranging paths being recalibrated (1) at periodic intervals (once or twice each year) or (2) whenever significant component or configuration changes have been made in the translator ranging path.

The calibrations of the translator ranging path delays have been performed in the past years with an R & D Zero Delay Device (ZDD) (Ref. 2). The ZDD was shipped at various times to the three 64-m antenna DSS and has been used successfully to make translator delay measurements. Recently, the design features of the R & D ZDD have been improved and incorporated into a field-worthy version called the Portable Zero Delay Assembly (PZDA). PZDAs have been fabricated for the DSN and a calibrated unit has now been supplied to DSS 14, DSS 43, and DSS 63. Operational test procedures for translator measurements with the PZDA have been written by DSN Network Operations and are currently being verified. The purpose of this article is to present pertinent design information as well as calibration test data on the PZDA.

II. Description

Figures 1 and 2 respectively show the original R & D ZDD and the new PZDA. For the PZDA, pads and step attenuators were made to be internal components of the assembly to simplify test procedures for field use. In addition, the PZDA includes some broadband filters and isolators (see Figs. 3 and 4) to suppress potential mismatch and higher order harmonic distortion errors. Suppressing these errors is especially important when calibrating the PZDA delays by the back-to-back method to be described later in this article. The tradeoff for a more accurate unit for field use is a longer delay through the PZDA because of the additional built-in components. All components including filters and isolators have at least ± 40 MHz bandwidths at their approximate uplink-downlink center frequencies of 2113 MHz, 2295 MHz, and 8415 MHz.

Figure 5 shows the S- and X-band mixer subassembly for the PZDA. This subassembly is a standard mixer assembly being used in the Block IV Doppler Translator Assembly and is also very similar to the mixer assembly in the R & D ZDD.

The test cables supplied with the PZDA as shown in Fig. 2 are phase-stabilized F282 cables made by the Flexco Co. in Denville, New Jersey. These cables were selected (instead of

the smaller diameter F182 cable used for the R & D ZDD) because of their lower loss and superior mechanical durability with flexing, especially at the type N-to-cable transition joints. Three 7.62-m (25 ft) F282 cables are supplied with each PZDA for the S-X signal paths and two 3.05-m (10 ft) F282 cables for the L.O. paths. The F282 cable has a delay characteristic of about 4.72 ns/m and attenuations of 0.66 dB/m in the 2.1 to 2.3-GHz range and 1.25 dB/m at 8.4 GHz.

III. Test Method

The PZDAs were calibrated by use of the back-to-back method which is depicted in Fig. 6. The PZDA on the right-hand side is the unit under test while the unit on the left is the comparison standard. The comparison standard is also a PZDA but differs in that the S-X isolators are reversed to permit signal to flow in the reverse direction (J6 and J7 ports to J3 port). When making S-S delay calibrations, the 182-MHz L.O. drive is turned on and simultaneously feeds port J1 of each unit. The uplink test signal (of approximately 2113 MHz) is fed into port J3 of the unit being tested. This uplink signal becomes up-converted to approximately 2295 MHz in the test unit and then down-converted back to 2113 MHz when it passes through the standard comparison unit. When measurements are to be made for S-X band delays, the 182-MHz L.O. drive is turned off and the 6.3-GHz L.O. drive is turned on to simultaneously feed port J5 of each unit. The 2113-MHz test signal becomes up-converted to approximately 8415 MHz in the test unit and down-converted back to 2113 MHz when passing through the standard comparison unit.

Insertion phase versus frequency measurements are made for an input test frequency range of 2113.5 ± 8.5 MHz using an HP 8410A Network Analyzer and a microwave source driven by a frequency synthesizer. Group delay is calculated from the slope of the insertion phase versus frequency data. It is necessary to (1) measure the delay of the total insertion delay of the back-to-back assemblies as shown in Fig. 6 and (2) measure separately the delays of any test cables (including pads) that were used to interconnect the test unit to the standard unit in the back-to-back configuration. The delay of the unit under test is then determined by subtracting the delay of the test cables and delay of the standard comparison unit from the total measured insertion delay. If the delay of the standard comparison unit is not known, then the delay of the unit under test can be determined by subtracting out the test cable delays from the total measured insertion delay and then dividing the net result by two. This latter method is valid only if both the test and standard units were built to the same specifications and are therefore electrically identical to within an acceptable tolerance.

For the test results of the article, the delay of the standard comparison PZDA was known and determined previously by connecting it to an improved R & D ZDD and calibrating it in the back-to-back configuration. The R & D ZDD (improved version) in this configuration was the basic primary standard and was used because it has S-S and S-X delays of 2.3 ns in each path which are known to accuracies of ± 0.2 ns (1σ). These accuracies were established previously from extensive testing and cross-comparisons.

After completion of the PZDA calibrations, the two 3-dB pads in the test unit as shown in Fig. 6 were replaced by two 20-dB pads (of nearly the same physical lengths and electrical delays) to restore the PZDA to its operational configuration of Fig. 3. The lower value (6 dB) padding was temporarily needed during the calibration because a relatively strong test signal level is required for the Network Analyzer insertion phase measurements.

IV. Test Results

Table 1 shows the final calibrated delays of the PZDAs that were sent to various DSSs. The applicable serial numbers and DSS identification are also tabulated. The accuracy of the delays are estimated to be better than ± 1.0 ns (1σ). Due to the fact that all components in the PZDA including isolators and filters are wide-band (see Section II of this article), the delay calibrations in Table 1 are applicable over a wide-band and apply to all S-S and S-X frequencies for DSN channels 5 through 27 listed in DSN documents.

The insertion losses of the PZDA in the final operational configuration were determined to be 54 ± 2 dB for the (S-S) path going from port J3 to J6 and 55 ± 2 dB for the (S-X) path going from port J3 to J7. The high insertion losses are mainly due to the two 20-dB pads (see Fig. 3) that are needed to attenuate an anticipated test signal level of +19 dBm to a level of about -20 dBm so that internal S- and X-band mixers will be operated in their linear regions. The strong test signal level of +19 dBm is derived at each 64-m DSS from the output of a 54-dB waveguide coupler which samples the 20-kW transmitter power.

V. Conclusion

A PZDA that is field-worthy, operationally easy to use, and accurately calibrated has been developed. A PZDA has been shipped to DSS 14, DSS 43, and DSS 63. Preliminary results

of Translator delay measurements from DSS 43 and 63 indicate the results obtained with the PZDA agree reasonably well with test data obtained in previous years with the R & D ZDD.

The standard comparison PZDA as well as calibration procedure documentation have been sent to the DSN Maintenance Center (DMC). Recalibrations of the PZDA in the future can be done by shipping the units to DMC.

References

1. Komarek, T., and Otoshi, T., "Terminology of Ranging Measurements and DSS Calibrations" in *The Deep Space Network Progress Report 42-36*, pp. 35-40, Dec. 15, 1976.
2. Otoshi, T. Y., Batelaan, P. D., Wallace, K. B., and Ibanez, F., "Calibration of Block 4 Translator Path Delays at DSS 14 and CTA 21" in *The Deep Space Network Progress Report 42-37*, pp. 188-197, Feb. 15, 1977.

Table 1. Calibrated PZDA delays

DSS	SN	S-S (ns)	S-X (ns)
14	2	18.8	14.3
43	3	18.1	14.2
63	4	18.2	13.9

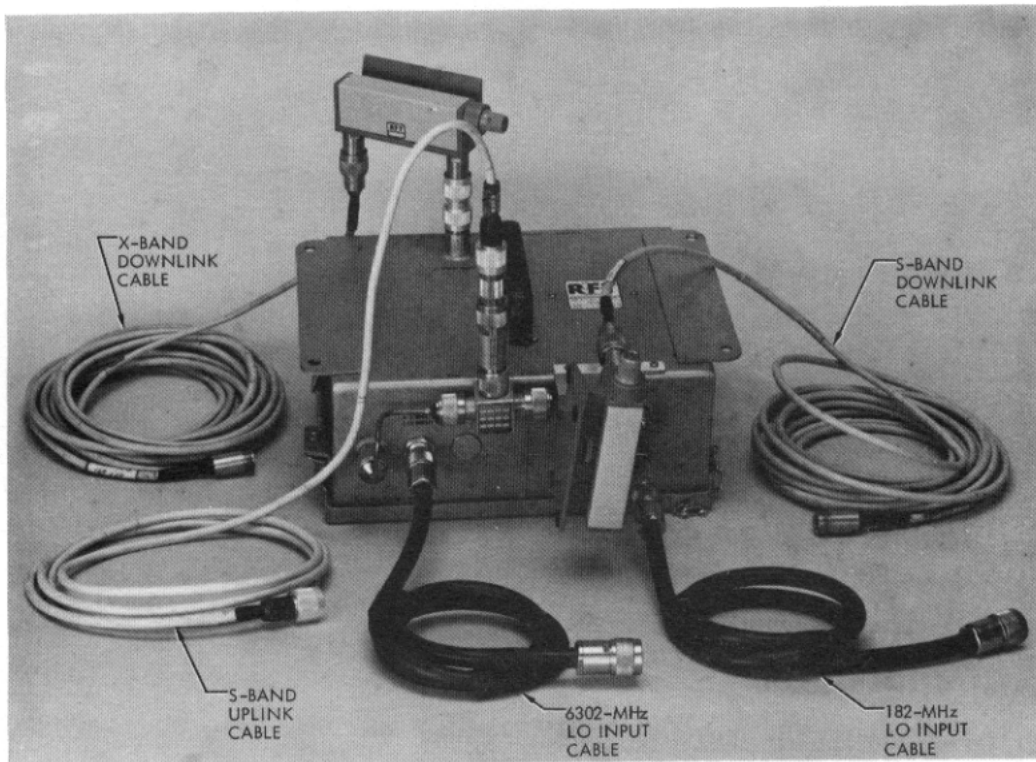


Fig. 1. R&D Portable Zero Delay Device with external test cables and attenuators

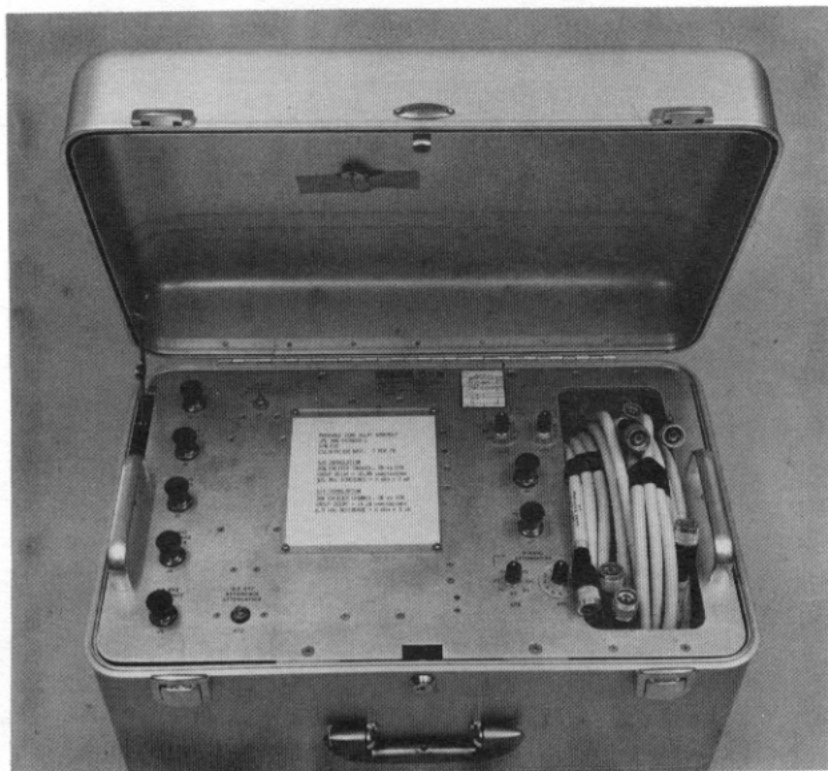


Fig. 2. DSN Portable Zero Delay Assembly

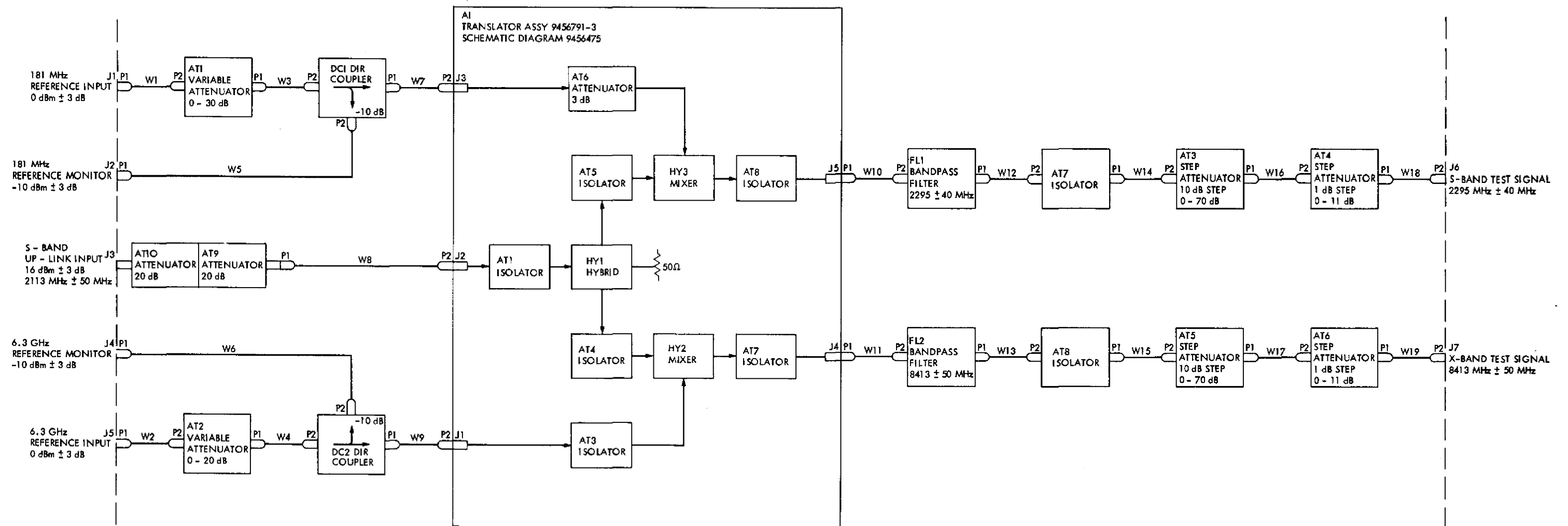


Fig. 3. Block diagram of Portable Zero Delay Assembly

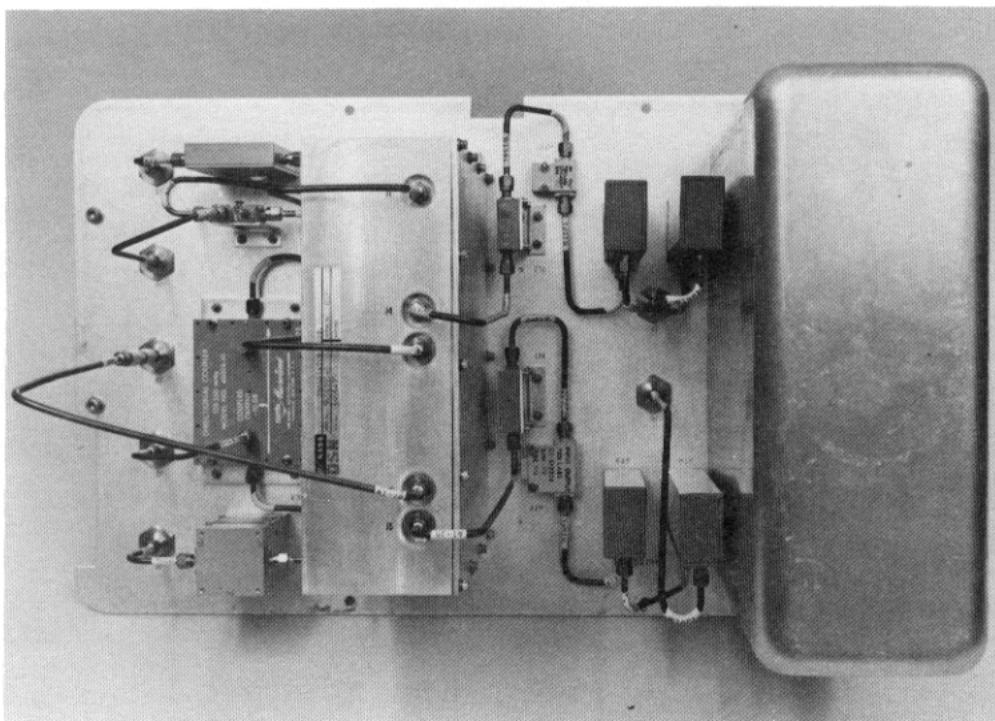


Fig. 4. Microwave components mounted on underneath side of front panel of Portable Zero Delay Assembly

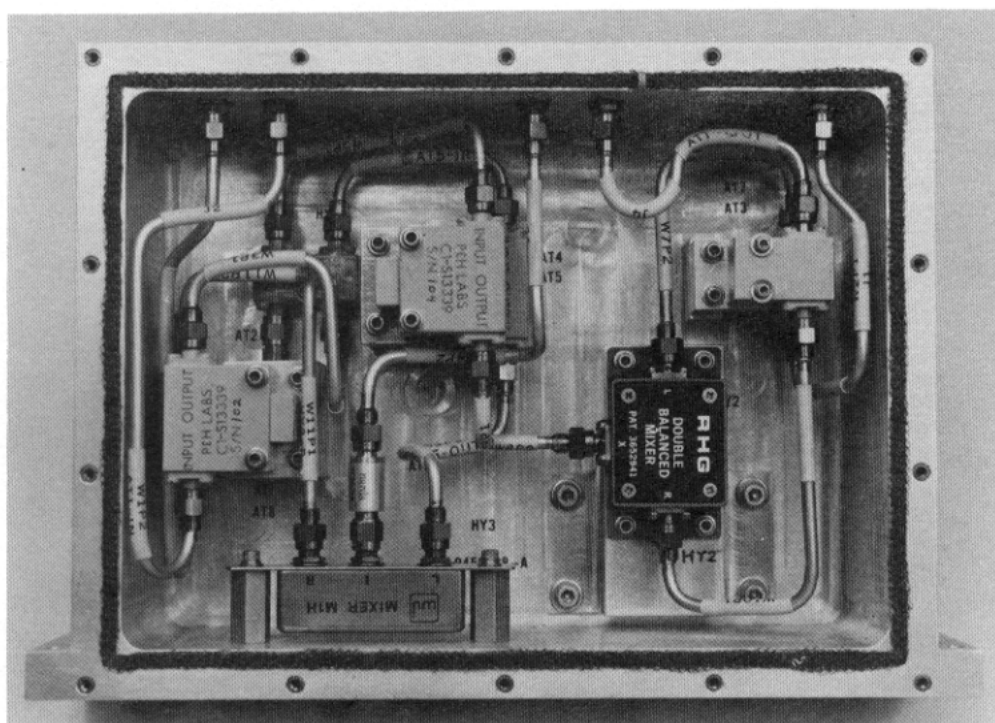


Fig. 5. S- and X-band mixer subassembly of Portable Zero Delay Assembly. Same as Translator Assembly 9456791-3

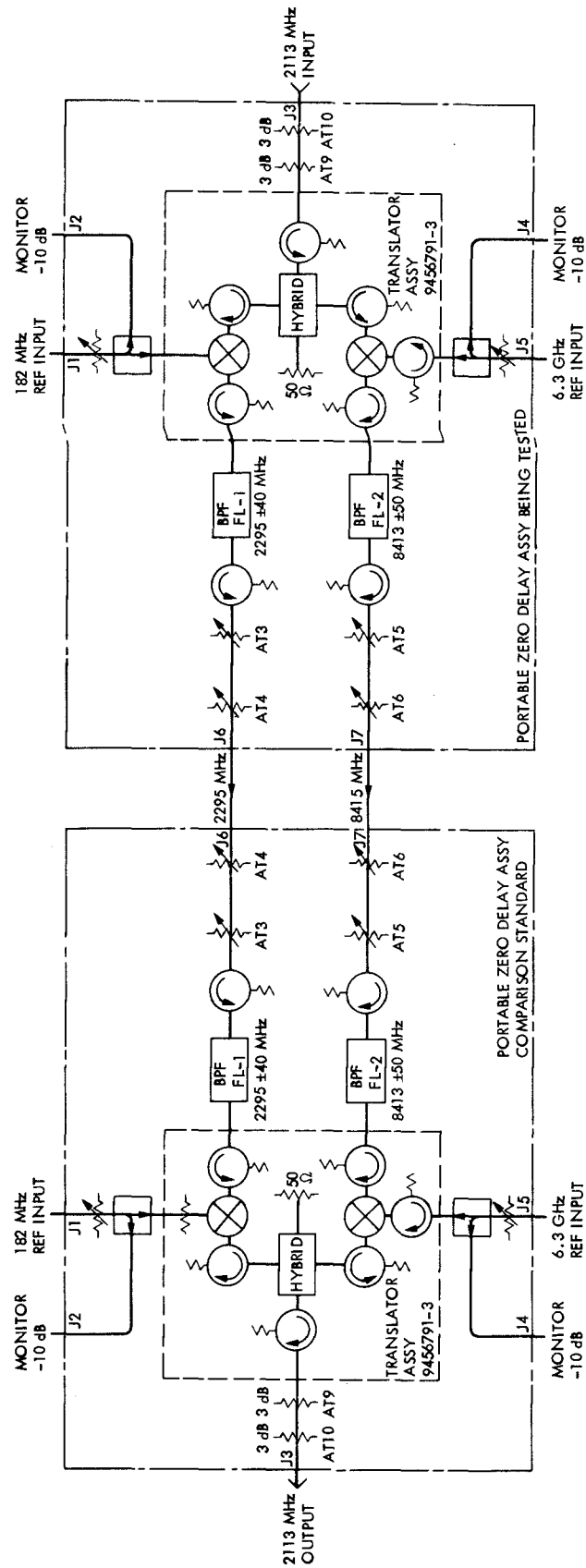


Fig. 6. Back-to-back test configuration